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Operation
UPSHOT-KNOTHOLE

NEVADA PROVING GROUNDS

March - June 1953

ACTIVITIES OF THE ARTILLERY TEST UNIT

[redacted]

ARTILLERY CENTER, FORT SILL, OKLAHOMA

Defense Nuclear Agency
6801 Telegraph Road
Alexandria, Virginia 22310-3398

21 August 1995

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER
ATTN:OCD/Mr. Bill Bush

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FOR THE DIRECTOR:

For Ardith Jarrett
JOSEPHINE B. WOOD
Chief, Technical Support

[redacted]

WT-709

This document consists of 41 pages

No. 15 of 70 copies, Series A

Report to the Test Director

ACTIVITIES OF THE ARTILLERY TEST UNIT

By

Col DeVere Armstrong

Artillery Center
Fort Sill, Oklahoma
September 1953

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FC/09530709

[redacted]

ABSTRACT

As directed by higher authority, the Commanding General, Artillery Center, was charged with the mission of detonating a T-124 (Mark 9) projectile at the time and place designated by the Test Director at the Nevada Proving Grounds (NPG).

The Artillery Test Unit (ATU) was organized at Ft. Sill, Okla., and there it conducted preliminary firing during March and April of 1953.

The ATU was stationed at Camp Desert Rock on 6 May 1953, under the following arrangement:

The ATU for the Nevada phase of the test performed its tasks on a mission basis as requested by the Chief, Armed Forces Special Weapons Project (AFSWP), but it remained under command of its own service.

The ATU was supported administratively and logistically by the Commanding General, Camp Desert Rock.

Further preliminary firing was conducted at NPG on 15 May 1953, and a dress rehearsal was fired on 22 May 1953. At 0830 on 25 May 1953 the T-124 (Mark 9) was successfully delivered and detonated over Frenchman Flat, with a calculated error from the predicted point (500 ft above Ground Zero) as follows: height, +8 yd; range, −54 yd; and deflection, 15 yd left.

This error was well within the limits prescribed by the Test Director—namely, to ensure a 90 per cent probability of not exceeding a height-of-burst error of ±100 ft.

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CHAPTER 1

OBJECTIVES

1.1 DEVELOPMENT OF DELIVERY TECHNIQUES

For the purpose of this test, four techniques of delivery will be analyzed. These techniques include: high-burst registration, spotting-round adjustment, silent adjustment, and muzzle-velocity error plus metro corrections.

One method, high-burst registration, is a previously established technique used with conventional artillery. The other three methods, spotting-round adjustment, silent adjustment, and muzzle-velocity error plus metro corrections, are new and are to be employed to increase the delivery of surprise fire to a maximum. Further detailed description of each of the above-mentioned techniques is presented in Chaps. 3 and 4.

1.2 OPERATIONAL PROCEDURES

The use of an atomic artillery projectile requires considerable detailed meteorological data and accurate survey information. In addition to the above, the troop organizations must be adequately trained. Although the techniques of delivery and procedures for delivery may change as a result of these tests, the currently prescribed procedures as outlined in Department of the Army Training Circular 16, 1 Apr. 1952, Department of the Army Training Circular 3, 11 Jan. 1952, and Department of the Army Training Circular 39, 28 Nov. 1951, were used. Briefly these procedures require an Ordnance Special Weapons Direct Support Company (SWDS) to monitor the mechanical portion of the atomic shell as well as to monitor the nuclear components.

The mechanical portion of the T-124 (Mark 9) shell was delivered to the gun position on D−1 day, and on D-day prior to the desired firing time couriers delivered the nuclear components, assembled the shell within the assembly van, set the fuzes after receipt of the desired fuze setting from the fire-direction center, and supervised the insertion of the shell into the gun tube. After the shell and powder charge were inserted, necessary firing data were placed on the 280-mm gun, and the gun was finally fired from the Atomic Energy Commission Control Point (CP) by remote control.

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CHAPTER 2

ORGANIZATION OF THE ARTILLERY TEST UNIT

By General Order No. 6, Headquarters 52d Field Artillery Group, dated 11 Apr. 1953, the Commanding Officer, 52d Field Artillery Group designated "A" Battery of the 867th Field Artillery Battalion as the Artillery Test Unit (ATU) for the full-scale test of the 280-mm gun. Organization of the ATU is described fully in Table 2.1. Most of the ATU personnel came from the 52d Field Artillery Group with technical assistance from the Departments of Gunnery, Observation, and Materiel of the Artillery School, the Post Signal Office, and the Post Ordnance Office, all at Ft. Sill, Okla.

Table 2.1—ORGANIZATION OF THE ARTILLERY TEST UNIT

Command group:
Commanding Officer, Col DeVere Armstrong
Deputy Commander, Col Berton E. Spivy
Executive Officer for administration and training, Lt Col G. T. Stump
Executive Officer for plans and operations, Maj L. Galperin
S-1, WOJG J. B. Yates, Jr.
S-2 and commo, Capt J. D. Farrar
S-3, Maj R. G. Marriott
Asst S-3, Maj D. P. McAuliffe
S-4, Maj J. K. Morton
Technical assistant for special weapons, Lt Col F. C. Healy
Chiefs of technical assistance groups from the Artillery School.
Gunnery, Lt Col R. E. Arn
Radar and Observation, Lt Col C. W. Dietz
Materiel, Maj F. W. Shelton
Battery A, 867th FA Battalion, Capt R. A. Erickson
Communications platoon, 1st Lt H. E. Callaghan
Survey information center, Maj C. R. Hill
Metro platoon, Capt R. C. Carnes
Radar platoon, 2d Lt D. D. Luce
Flash platoon, 2d Lt M. J. O'Connell
Ordnance Detachment (SWDS), Capt N. G. Christensen
Mitchell camera team, 2d Lt D. E. Black
Chronograph, F. E. Szalack
Ordnance field-maintenance team, W. D. Gibson

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CHAPTER 3

OPERATIONS AND INSTRUMENTATION: FT. SILL PHASE

3.1 RESEARCH

3.1.1 Gunnery Background

The Ft. Sill phase of the 280-mm gun test was preceded by a technique developmental phase which included a review of current gunnery techniques and a study of new potential techniques to develop the theoretical solution best adapted to the delivery of an atomic shell.

A basic artillery technique for delivering surprise, unobserved fire is based upon the correction of chart data by registration. The center of impact of a group of rounds (usually six) is adjusted onto a target of known location relative to the gun. Comparison of the data of actual firing with the basic chart data to the registration point produces the corrections to be applied to the chart data for other targets in the same vicinity to bring fire on them. Corrections obtained by registration are valid only for the conditions of weather, weapon, and ammunition then existing; when any of these conditions change, a new registration must be conducted. The area over which registration corrections produce satisfactory results is limited to approximately 4000 yd in range and 8000 yd in direction surrounding the registration point.

A refinement of this basic technique employs the solution of a meteorological message concurrent with registration. By stripping these weather corrections from the total registration correction, a residual correction for conditions of weapon and ammunition is obtained. The weapon and ammunition are considered to be relatively stable; therefore this residual correction can be applied to the correction for the large variable—weather—computed for the targets to be attacked. This refinement reduces the need for frequent registrations and somewhat relaxes the area limitations imposed upon the basic technique.

3.1.2 Evaluation

The techniques just described produce adequate results for the relatively short ranges fired by light and medium weapons. However, they contain significant defects when applied to heavy and very heavy artillery. These defects are a loss of surprise through registration, the large ammunition expenditures necessary to maintain current corrections, and the fact that the validity is restricted to a limited area of space and time.

3.1.3 Solution

In an effort to develop a theoretical technique to overcome these defects, three basic assumptions were made. They were as follows: (1) A successful solution of the problem must retain the capability of tactical surprise; (2) it must be economical of ammunition since weapon wear will be rapid and ammunition supplies limited; and (3) a satisfactory technique

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must be found for the delivery of atomic projectiles over a wide area by a small number of weapons; this technique must be applicable throughout the range and direction capabilities of the weapon.

Recent developments in the ordnance field were incorporated into the development of the theoretical solution. These were: (1) firing tables presenting ballistic effects on a two-dimensional argument thus allowing a more precise determination of unit corrections than was heretofore available; (2) improved quality control of shells and propellants, resulting in a significant decrease in round-to-round variation in performance; (3) a field chronograph to measure muzzle velocities under tactical conditions, permitting determination of precise corrections for weapon condition.

Two basic theoretical solutions were evolved. These solutions could be varied to fit different tactical requirements. They were: (1) The prediction of data through the application of computed corrections for variation from standard for the weather, the rotation of the earth, the weight of the projectile, and the muzzle velocity and (2) a standard six-round high-burst registration concurrent with computation of corrections cited above. Comparison of these two sets of concurrent data may (or may not) produce a small residual to be applied to predicted data for targets to be attacked. The application of this small residual, when present, corrects minor errors in survey, weather measurement, firing-table effects, etc., that are not predictable.

The variations employed included: (1) A one-round spotting adjustment: this variation reduces ammunition expenditure and increases surprise potential. However, corrections obtained are subject to random errors of dispersion. (2) Radar silent adjustment: by tracking with radar an inert round or one set to burst on impact, corrections on the order of the single spotting-round adjustment are obtained. Because the shell does not burst in the air, surprise capability is retained. However, the method is subject to random errors of dispersion.

Both basic methods, and the variations thereof, were tested by the firings at Ft. Sill on 17 March to 9 April. The results of these firings are presented in Chap. 6.

3.2 RECONNAISSANCE AND SURVEY

Map and ground reconnaissance at Ft. Sill resulted in the selection of a burst point and two gun positions paralleling the physical requirements for the Nevada test. These requirements were: the direction of fire between 0 and 30° true north; a range of approximately 11,000 yd; and a height of burst of 500 ft.

Survey control was extended to the necessary installations from nearby Coast and Geodetic Survey markers. The accuracy of location was 1 in 2000 or better.

3.3 INSTRUMENTATION

The instrumentation employed during the tests was as follows:

1. A four-station flash-observation base for burst location.
2. A four-station observation base using organic battery commander's telescopes (BC scopes) for burst location.
3. Four radar sets: two AN/MPQ-10's and two AN/MPQ-22's for locating bursts or predicted points.
4. A Sperry Doppler type field chronograph for measuring muzzle velocities.
5. A Mitchell high-speed camera and clock wired into the firing circuit for measuring projectile times of flight to one-hundredth of a second.
6. Standard powder-temperature thermometers for measuring propellant temperatures, beginning 72 hr prior to each firing.
7. An artillery weather station for providing hourly electronic weather measurements.

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3.4 TESTS FROM 17 MARCH TO 9 APRIL 1953

3.4.1 Firing

Four 280-mm firings were conducted during the period 17 March to 9 April to test the theoretical solutions developed in the research phase and to evaluate the burst location methods employed. Two weapons were used, each firing a normal and a reduced charge. The weapons were fired from different positions. Preliminary firing by a 240-mm howitzer was used only to check instrumentation and communication before each 280-mm firing. Therefore the results of the 240-mm firings are not applicable to this report.

The sequence of each firing was as follows: first, conditioning rounds were fired to warm up and seat the weapon. These were followed by a standard six-round high-burst registration fired with data corrected for weather, weapon, and ammunition. Then a silent adjustment was made. And finally a verifying round, either an Operational Suitability Test (OST) or a T-123, was fired with data corrected by the high-burst registration.

The first round of the high-burst registration was utilized as a spotting-round adjustment to conserve time and ammunition. The results of these firings are presented in Chap. 6. An analysis of the results is presented in Chap. 7.

3.4.2 Employment of Radar Sets

The radar technique described in Appendix A was used to locate and verify air bursts of projectiles fired in the high-burst registration. They were also used to locate those bursts fired to warm up the gun as well as locating a predicted point on the trajectory of a projectile fired for silent registration.

3.4.3 Flash Ranging

Flash-ranging procedure as prescribed in FM 6-120 was used. An instrument, spotting M2, and a telescope, BC, M65, were utilized at each observation post. A board, plotting, M5, was used at the flash-ranging central. Horizontal control was provided by the spotting instruments. Vertical control was provided by averaging the data obtained from all instruments.

3.4.4 Ballistic Meteorology

During the Ft. Sill phase of the tests, the guns received meteorological support from a station located approximately 7 miles west of the gun position. Because of fairly even terrain, measurements taken at this station were entirely valid for the firing during this phase of the tests.

The station was equipped with the rawin set AN/GMD-1A and associated electronic weather equipment. Two operating teams computed the meteorological data independently. Electronic sounding flights were made every hour on the hour during test firing, with messages delivered to the fire-direction center approximately 30 min after release of the balloon. The methods used were in accordance with TM 20-240 and TM 20-241.

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CHAPTER 4

OPERATIONS AND INSTRUMENTATION: NEVADA PHASE

4.1 RECONNAISSANCE AND SURVEY

4.1.1 Preliminary Reconnaissance

An area reconnaissance by air, map, and ground was conducted in December 1952. At this time personnel from the office of the AEC Test Director directed that the weapon position would be located so that the direction of fire would be between 0 and 30° of true north. A back plot was made from Ground Zero, and an approximate gun area was decided upon. A hasty reconnaissance for radar set locations and observation posts was made at this time; no positions were finalized.

4.1.2 Final Reconnaissance and Survey

In January 1953 a reconnaissance party and survey crew from the Artillery School returned to NPG to complete reconnaissance and perform the necessary survey operations to tie in all positions. At this time final locations for all installations were determined and staked in. The following stations were located on the survey: Ground Zero, four gun positions, four BC scope OP's, four flash OP's, five radar sites (one site was an alternate), and one Mitchell high-speed camera site.

Accuracy of certain station locations was checked by Silas Mason, Inc., the civilian engineering contractor, and by members of Upshot-Knothole Project 6.12. Verification of surveyed locations indicated differences in the various surveys of approximately 1 m in station locations, and it was decided to make no changes in location based on other survey.

It is of interest to note that the triangulation was completed using T-2 theodolites, which are capable of giving direct readings to the nearest 1 sec. Computation was by seven-place logarithms.

4.2 INITIAL FIRING

Preliminary firing was conducted on 15 May. This firing was conducted in the same manner as had been planned for the Mark 9 delivery and was used to test instrumentation, materiel, and communications.

A standard six-round high-burst registration was fired with data corrected for weather, weapon, and ammunition. This registration was fired over Ground Zero. An OST round was fired as a verifying round with data corrected by the high-burst registration. The first round of the high-burst registration was utilized as a spotting-round adjustment to conserve time and ammunition. The results of firing are presented in Chap. 6. An analysis of the results is presented in Chap. 7.

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Due to the quantity of extremely sensitive equipment in the target area and because of excessive ground clutter which precluded obtaining burst locations by radar, no silent adjustments were fired at NPG.

Flash-ranging procedure, as prescribed in FM 6-120, was used. Equipment was the same as that used for the Ft. Sill phase. Spotting instruments provided only horizontal control and the BC scopes provided only vertical control. This change from the technique used during the Ft. Sill phase was based on experience gained during that phase. Two of the targets fired on were of such range that they plotted off the plotting board. To overcome this problem, the observation posts were replotted, leaving the rearmost observation post off, and the burst was located using only three-ray instead of four-ray plots.

4.3 DRESS REHEARSAL

A dress rehearsal was conducted on 22 May as a final check on instrumentation, materiel, communications, firing circuits, and duties of personnel, for both ATU and necessary elements of AEC. A standard six-round high-burst registration was fired with data corrected for weather, weapon, and ammunition. This registration was fired over Ground Zero. An OST round was fired as a verifying round with data corrected by the high-burst registration. The first round of the high-burst registration was utilized as a spotting-round adjustment to conserve time and ammunition. The results of firing are presented in Chap. 6. An analysis of the results is presented in Chap. 7.

Flash-ranging operations for the dress rehearsal were the same as for the initial firing on 15 May 1953.

4.4 SHOT DATE

At 0830 on 25 May the Mark 9 round was fired. A seven-round high-burst registration was fired with data corrected for weather, weapon, and ammunition. This registration was fired over Ground Zero. The Mark 9 round was fired with data corrected by the high-burst registration. The results of firing are presented in Chap. 6. An analysis of the results is presented in Chap. 7.

Flash-ranging operations for the shot date were the same as those for the initial firing. No attempt was made to observe the burst of the Mark 9 round.

4.5 EMPLOYMENT OF RADAR SETS

The radar technique used was the same as that described in Appendix A.

4.6 BALLISTIC METEOROLOGY OPERATIONS

The ballistic meteorology station was established in the gun-position area (200 yd SE of the base piece) at NPG. Two entirely independent sections were organized, so that completely different but parallel instrumentation was effected both aloft and on the ground. Reduction of data was similarly independent, and messages were compared before forwarding to the fire-direction center. Due to a high state of operator proficiency, results from the two messages were exceptionally uniform in every case. Minor differences were charged to atmospheric turbulence, and the messages were meaned for the final result.

Messages were scheduled to provide a constant flow of fresh metro data for the fire-direction center. Times and line numbers varied according to the firing requirements.

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CHAPTER 5

ORDNANCE SPECIAL WEAPONS DIRECT SUPPORT OPERATIONS

5.1 PREPARATION AND TRAINING

During the last week in March, the Operations Section of the 136th Ordnance Company (SWDS) went to Killeen Base, Tex., in order to train on actual stock-pile rounds in preparation for the Nevada phase of the 280-mm gun test. These personnel performed both mechanical functional surveillance on stock-pile rounds and nuclear surveillance on stock-pile components. In the first week of May, the Operations Section of the 136th Ordnance Company (SWDS) was sent to Camp Desert Rock, Nev., as a part of the ATU to participate in the Nevada phase of the 280-mm gun test. An officer and an enlisted man were sent to Nevada in April as an advanced party in order that working space would be available upon arrival and that all preliminary arrangements would be made. The Sixth Army representatives in charge of the truck transportability portion of Phase I, 280-mm gun test, requested technical advice concerning their portion of the test. The officer representative of this organization in the ATU advance party acted in this capacity during meetings held prior to the 50-mile road test conducted by Camp Desert Rock personnel.

5.2 FT. SILL OPERATIONS

The Ft. Sill phase of the 280-mm gun test began in March 1953. The first OST round was fired on 19 Mar. 1953, the second on 2 Apr. 1953, and the third on 9 Apr. 1953. A total of four OST rounds were issued to the Post Ordnance Property Officer, Ft. Sill, and were marked for the 136th Ordnance Company (SWDS). Three of the four rounds were expended, and the unexpended round was returned to Sandia Base, N. Mex., along with the salvaged remains of the first three OST rounds. A complete functional surveillance was performed on all rounds prior to the firing of the first three.

5.3 PREPARATION FIRING AT NPG

On 15 and 21 May 1953 two of the five OST rounds sent to NPG were assembled using dummy nuclear components. They were fired by "A" Battery, 867th Field Artillery Battalion.

This makes a final total of five OST rounds that were fired by the ATU at Ft. Sill and NPG. The nuclear components from these rounds were recovered the day of firing and were returned to Building 10 for loading in the H-118 containers in preparation for shipment back to Sandia Base. On 27 May 1953 the salvaged remains of the two OST rounds fired at NPG and both sets of recovered dummy nuclear components plus the three unexpended OST rounds were turned in at Sandia Base by a representative of ATU.

5.4 TEST ROUNDS, NPG PHASE

The original two maneuver rounds which were to be used in the actual 25 May 1953 firing were exchanged for two other rounds with later modifications. The AEC representatives felt that the original maneuver rounds were serviceable for firing, but the AEC Test Director requested that the round to be fired with U^{235} components be equipped with the latest modifications. Two new breech-block assemblies were flown from Picatinny Arsenal to Sandia Base for use in the test. These breech blocks arrived too late to be included in the seven weapons shipped in Phase I, so the AEC decided to modify two additional stock-pile rounds and send them out by air. The newly modified rounds were flown to NPG from Sandia Base and remained in AEC custody. The AEC at no time during the test officially transferred to military custody any of the T-124 rounds or nuclear components actually scheduled for the live-round firing on 25 May 1953 (D-day).

5.5 SURVEILLANCE OF TEST ROUNDS

On D−2 the squab initiators to be used in the live-round were counted for neutron background in both AEC and 136th Ordnance Company (SWDS) counting systems. This was done in order to give more dependable and accurate counting results. The resultant neutron background counts for both sessions were so close that AEC representatives requested that only one set of counts be made on D−1. They also requested that the AEC neutron-counting system be utilized for these counts since it was located within the nuclear-storage building (Building 4). This organization concurred with the one-count request of the AEC since representatives of this unit were still requested by the AEC to be present at future counting sessions which took place on D−1 and D-day. On D−1 a limited check was made of the rounds in Building 10. The squabs, squab-cases, and retainer disk were checked for proper seating. The two rounds were then loaded in the vans with their respective H-119 containers in preparation for the move to the gun position on D-day.

5.6 SHOT DATE

At H−$4\frac{1}{2}$ hr on D-day (H-hour is detonation time) the two vans and the $\frac{3}{4}$-ton truck with nuclear components moved to the gun position where the disassembly of the live-round was accomplished by a team from "A" Battery, 867th Field Artillery Battalion. The insertion of nuclear components and the reassembly of the shell were accomplished by an assembly team from this organization. AEC representatives were present at the time of assembly for the purpose of checking the serial numbers of the components as they were assembled into the round. This was done because the custody of the components was still the responsibility of the AEC. Also present, at the request of the AEC Test Director, was a representative of Sandia Corporation to observe the mechanical portion of the assembly and an LASL representative to observe the nuclear portion of the assembly. The assembly was completed at 0745, and the round was taken to the gun at 0805.

5.7 RECEIPT OF SHELLS AND DUMMY NUCLEARS AT NPG

On 4 May 1953, seven T-124 rounds (five OST and two maneuver) and two sets of dummy nuclear components were flown by helicopter from Nellis AFB, Las Vegas, Nev., to NPG. This organization accepted the two sets of dummy nuclears by signing the standard Courier Receipt at the time of arrival of the helicopters on the Yucca Lake Air Strip. The two sets of dummy nuclears were then taken to Building 4, NPG (nuclear-storage building), where a check of serial numbers was made. The seven T-124 rounds were taken to Building 10, NPG

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(assembly building). The following day, a limited functional surveillance was completed on all seven rounds by an assembly team from the 135th Ordnance Company (SWDS), Fort Bragg, N. C. On 6 May 1953 all seven rounds were transported in 2½-ton trucks for 50 miles on secondary roads within NPG. The following day the 135th Ordnance Company (SWDS) team again completed a limited functional surveillance on all the rounds.

On 8 May 1953, the seven T-124 rounds were transferred to the ATU. Two days later, after completion of a complete functional surveillance by the 135th Ordnance Company team, the two maneuver rounds were transferred to AEC custody as per Field Command Fragmentary Operations Order 38-53, dated 27 Apr. 1953. A complete functional surveillance was accomplished on the remaining five OST rounds by this organization.

All components (both mechanical and nuclear) were received in serviceable condition after the completion of Phase I of the 280-mm gun test.

5.8 SECURITY

All local and in-transit security was provided by the AEC Security Service. The excellent cooperation given this organization by the AEC personnel at NPG greatly enhanced the successful completion of the mission of this unit.

CHAPTER 6

RESULTS

6.1 FT. SILL AND NPG PHASES

6.1.1 Gunnery Techniques

The results of the Ft. Sill and NPG firings are presented in Tables 6.1 to 6.7. Opposite each gunnery method is listed the error resulting from a verifying round fired with that technique. To conserve ammunition and time, the verifying round in each test was fired with data corrected by the high-burst registration. From the location of this burst, the computed location of a verifying round fired with data corrected by the other methods was determined. An analysis of these results is presented in Chap. 7.

Table 6.1—ERROR OF VERIFYING ROUND FROM PREDICTED BURST POINT*

(Ft. Sill, 19 Mar. 1953)

	Direction		Range		Height	
Technique	Mils	Ep†	Yd	Ep†	Ft	Ep†
Six-round high-burst registration	L1	4.4	−14	0.3	+20	0.4
Single spotting-round adjustment	L2	8.8	−58	1.1	+68	1.3
Muzzle-velocity error plus metro	0	0	+60	1.2	−31	0.6
Silent adjustment	0	0	+31	0.6	−115	2.3

*A reduced charge was used.
†Error predicted.

Table 6.2—ERROR OF VERIFYING ROUND FROM PREDICTED BURST POINT*

(Ft. Sill, 26 Mar. 1953)

Technique	Direction		Range		Height	
	Mils	Ep†	Yd	Ep†	Ft	Ep†
Six-round high-burst registration	R2	8.8	+132	2.2	−113	3.1
Single spotting-round adjustment	R2	8.8	+45	0.8	−94	2.6
Muzzle-velocity error plus metro	R2	8.8	+132	2.2	−32	0.9
Silent adjustment	R5.5	24.4	+174	3.0	−10	0.3

*A normal charge was used.
†Error predicted.

Table 6.3—ERROR OF VERIFYING ROUND FROM PREDICTED BURST POINT*

(Ft. Sill, 2 Apr. 1953)

Technique	Direction		Range		Height	
	Mils	Ep†	Yd	Ep†	Ft	Ep†
Six-round high-burst registration	R1	4.2	+25	0.4	−13	0.4
Single spotting-round adjustment	R1	4.2	+4	0.07	+62	1.8
Muzzle-velocity error plus metro	R1	4.2	+24	0.4	+20	0.6
Silent adjustment	R1	4.2	−13	0.2	+101	3.0

*A normal charge was used.
†Error predicted.

[redacted]

Table 6.4—ERROR OF VERIFYING ROUND FROM PREDICTED BURST POINT*

(Ft. Sill, 9 Apr. 1953)

	Direction		Range		Height	
Technique	Mils	Ep†	Yd	Ep†	Ft	Ep†
Six-round high-burst registration	R1	4.7	−70	1.4	−131	2.6
Single spotting-round adjustment	R1	4.7	−13	0.3	−34	0.7
Muzzle-velocity error plus metro	R3	14.1	−37	0.7	−148	2.9
Silent adjustment	L1	4.7	−43	0.8	−245	4.8

*A reduced charge was used.
†Error predicted.

Table 6.5—ERROR OF VERIFYING ROUND FROM PREDICTED BURST POINT*

(NPG, 15 May 1953)

	Direction		Range		Height	
Technique	Mils	Ep†	Yd	Ep†	Ft	Ep†
Six-round high-burst registration	0	0	+134	2.3	+49	1.3
Single spotting-round adjustment	L2	9.2	+3	0.05	+142	3.8
Muzzle-velocity error plus metro	R1	4.6	+184	3.1	+32	0.9
Silent adjustment‡						

*A normal charge was used.
†Error predicted.
‡Not fired.

[redacted]

Table 6.6—ERROR OF VERIFYING ROUND FROM PREDICTED BURST POINT*

(NPG, 22 May 1953)

Technique	Direction		Range		Height	
	Mils	Ep†	Yd	Ep†	Ft	Ep†
Six-round high-burst registration	L0.8	3.7	+76	1.3	−32	0.9
Single spotting-round adjustment	L4.1	18.9	+51	0.9	−113	3.1
Muzzle-velocity error plus metro	R0.9	4.1	+190	3.2	−3	0.1
Silent adjustment‡						

*A normal charge was used.
†Error predicted.
‡Not fired.

[redacted]

Table 6.7—FIRING OF THE T-124 SHELL

Location: NPG
Date: 25 May 1953
Firing data: Azimuth, 330.3 mils
Fuze setting, 18.9 sec
Quadrant elevation, 154.4 mils
Normal charge
Data used to determine firing data:
Chart data: Direction, 335.3 mils
Range, 10,956 yd
Height of burst, −184 ft
Metro used: Wind direction, 3500 mils
Wind speed, 20 mph
Air density, 89.2 per cent
Air temperature, 53°F
Weight of projectile: 800 lb
Powder temperature: 55°F
Muzzle velocity used uncorrected for powder temperature: 2058.9 ft/sec
Correction for barrel curvature: +2.90 mils
Latitude: 36°N
Drift correction: L2.0 mils
Residual corrections determined from high-burst registration:
Direction, L2.7 mils
Fuze setting, −0.08 sec
Quadrant elevation, −0.93 mil
Correction for drift difference between T-123 and T-124 shells: R0.4 mil
Correction to fuze setting for difference between single- and triple-fuze systems: +0.18 sec
Time of flight determined from Mitchell high-speed camera: 18.694 sec
Fuze error: −0.206 sec
Muzzle velocity developed: undetermined

Error of verifying round (T-124 atomic shell) from predicted point

Technique	Direction Mils	Direction Ep*	Range Yd	Range Ep*	Height Ft	Height Ep*
Six-round high-burst registration	L1.4	6.4	−54	0.9	+24	0.65
Single spotting-round adjustment	L1.8	8.3	+43	0.7	−9	0.24
Muzzle-velocity error plus metro	R1.7	7.8	−16	0.3	+30	0.8
Silent adjustment†						

*Error predicted.
†Not fired.

[redacted]

Table 6.8—BURST LOCATIONS WITH RESPECT TO PREDICTED POINT

Round No.	Flash: Direction, mils	Flash: Range, yd	Flash: Height, ft	BC scope: Direction, mils	BC scope: Range, yd	BC scope: Height, ft	Radar: Direction, mils	Radar: Range, yd	Radar: Height, ft
Test 1, Ft. Sill Phase 19 Mar. 1953									
1	R1	+75	−212	0	+66	−212	L3	+84	−5
2	0	+148	−230	0	+148	−191	L6	+212	+214
3	0	+27	−107	0	+25	−71	L1	+54	+164
4	L1	−14	−146	L1	+5	−149	L2	+5	+13
5	R1	−52	−143	0	+16	−113	L3	+14	−26
6	L1	+4	−146	L1	+6	−128	R2	+32	−242
HB	0	+31	−164	0	+33	−140	L3	+48	−16
OST	L1	−14	+20	R2	+41		R2	+2	−77
Silent adj.							R4	0	−132
Test 2, Ft. Sill Phase 26 Mar. 1953									
1	L1	−60	+178	L1	−69	+76	0	−77	+96
2	0	+148	−53	R1	+125	−53	L3	+193	−62
3	L2	+257	−176	0	+185	−146	L1	+247	−218
4	L1	+85	−45	0	+70	−26	L2	+76	−34
5	R1	−76	−62	R1	−83	−41	0	−62	−123
6	0	+9	−56	R1	+1	−17	L2	+100	−74
HB	0	+64	−35	R0.5	+38	−34	L1	+56	−83
OST	L1	+173	−116	R2	+132	−113	Lost		
Silent adj.							L2.5	−4	−137
Test 3, Ft. Sill Phase 2 Apr. 1953									
1	0	−13	−134	L1	−9	−116	R3	+24	−173
2	L1	+1	−119	L1	−6	−95	R2	+55	−152
3	L2	−38	−71	L1	−8	−47	R2	−25	−122
4	0	−183	+16	0	−141	+49	R5	−191	+22
5	R1	+80	−140	R1	+71	−110	R1	+200	−92
6	R2	−93	−65	R1	−84	−38	R1	−39	−161
HB	0	−40	−86	0	−34	−59	R3	−84	−87
OST	R1	+74	+16	R1	+70	+25	R3	+91	+73
Silent adj.							0*	+4	−173
							R5*	−21	−101

[redacted]

Table 6.8—(Continued)

Round No.	Flash Direction, mils	Flash Range, yd	Flash Height, ft	BC scope Direction, mils	BC scope Range, yd	BC scope Height, ft	Radar Direction, mils	Radar Range, yd	Radar Height, ft
				Test 4, Ft. Sill Phase 9 Apr. 1953					
1	R2	−15	−260	R3	−38	−257	Lost		
2	R2	+15	−61	R2	+5	−59	L5	−38	−104
3	R3	+182	−263	R2	+174	−248	R6	+180	−26
4	R2	+66	−233	R3	+78	−215	R2	+128	−101
5	R1	+29	−116	R2	+29	−116	Lost		
6	R2	+35	−104	R1	+7	−83	Lost		
HB	R2	+52	−173	R2	+42	−163	R4	+154	−61
OST	R1	−78	−113	R1	−70	−131	Lost		
Silent adj.							R4	+15	−49
				Test 1, NPG Phase 15 May 1953					
1	R3	+128	−227	R2	+109	−179			
2	R1	+10	−176	R2	+49	−107			
3	L1	−286	+22	R2	−262	+46			
4	0	+41	−152	R2	+89	−116			
5	R1	−24	−104	R3	−35	−83			
6	R1	+103	−167	R2	+108	−167			
HB	R1	−3	−134	R2	+10	−101			
OST	0	+134	+49	0	+100	+76			
				Test 2, NPG Phase 22 May 1953					
1	R5.3	+143	+49	R2.0	+143	+61			
2	L0.3	+228	−68	R2.3	+250	−69			
3	R2.0	+152	−68	R4.6	+175	−59			
4	R1.5	+129	−56	R2.3	+142	−38			
5	R1.7	−43	−11	R2.1	+8	+25			
6	L0.1	+106	−35	R2.2	+84	−23			
HB	R2.0	+118	−32	R2.3	+130	−17			
OST	L0.8	+76	−32	L0.7	+127	−56			
				Test 3, NPG Phase 25 May 1953					
1	R2.8	−63	+40	R2.3	−34	+67			
2	R3.7	+62	−11	R3.2	+34	+10			
3	R1.9	+84	−38	R1.7	+61	−17			
4	R1.2	+140	−35	R2.1	+110	−23			
5	R2.2	+39	+37	R1.5	+24	+52			
6	R2.4	−7	+28	R1.5	−14	+43			
7	R2.0	−20	+19	R0.5	−10	+25			
HB	R2.3	+34	+7	R1.9	+24	+22			
Mark 9†							L1.4	−54	+24

*Readings for radar 3.
†Location determined by AEC.

[redacted]

Table 6.9—FUZE SETTING VS TIME OF FLIGHT*

Fuze setting	Time of flight	Error	Fuze setting	Time of flight	Error
		Normal Charge			
18.8	19.17	+0.37	20.2	20.08	−0.12
18.8	19.00	+0.20	20.2	20.12	−0.08
18.8	18.73	−0.07	20.2	20.44	+0.24
18.8	18.97	+0.17	20.3	19.96	−0.34
18.8	19.06	+0.26	20.3	20.32	+0.02
18.8	18.87	+0.07	20.3	20.63	+0.33
18.8	18.78	−0.02	24.7	24.87	+0.17
18.9	18.40	−0.50	25.1	25.63	+0.54
18.9	18.39	−0.51	25.1	25.41	+0.31
18.9	18.81	−0.09	25.1	25.26	+0.16
18.9	19.10	+0.20	25.1	25.64	+0.54
18.9	18.81	−0.09	30.3	30.34	+0.04
18.9	19.33	+0.43	31.4	31.71	+0.31
18.9	19.23	+0.33	31.7	31.84	+0.14
18.9	19.14	+0.24	31.8	32.06	+0.26
18.9	18.89	−0.01	32.3	32.64	+0.34
18.9	19.09	+0.19	35.6	36.46	+0.86
18.9	19.11	+0.21	41.5	41.51	+0.01
18.9	18.93	+0.03	42.9	42.84	−0.06
19.5	19.10	−0.40	45.1	45.30	+0.20
19.5	19.65	+0.15	46.3	46.56	+0.26
19.5	19.35	−0.15	48.3	48.70	+0.40
19.6	19.58	−0.02	50.0	50.41	+0.41
19.6	19.56	−0.04	50.0	50.84	+0.84
19.6	19.46	−0.14	50.0	50.37	+0.37
20.2	20.24	+0.04	50.0	50.16	+0.16
			50.1	50.25	+0.25
		Reduced Charge			
24.5	24.76	+0.26	25.2	25.30	+0.10
24.5	24.55	+0.05	25.2	25.28	+0.08
24.5	24.86	+0.36	25.3	25.60	+0.30
24.5	24.60	+0.10	25.4	25.14	−0.26
24.6	24.55	−0.05	25.4	25.56	+0.16
25.2	25.49	+0.29	25.4	25.10	−0.30
25.2	25.27	+0.07			
		OST and Mark 9			
18.7	18.97	+0.27	19.7	19.60	−0.10
18.9	18.65	−0.25	24.4	24.40	0
19.1	18.93	−0.17	25.3	25.18	−0.12

*Recorded by Mitchell high-speed camera.

[redacted]

6.1.2 Burst Location

Burst locations obtained by flash base, BC scope base, and radar are presented in Table 6.8. The flash base and the BC scope base both furnished reliable burst locations within the allowable limits of accuracy. Discrepancies in locations between the two methods were minor and did not significantly affect the results of firing.

Radar performance was erratic. Design characteristics of the two types of sets tested were unfavorable for the mission assigned. A large percentage of bursts were not located at all. Of those located, many were unreliable; however, the reliable locations were quite usable. Radar locations of the silent adjustments were usable in three out of four cases. At NPG ground clutter precluded use of radar in determining burst locations; therefore the silent adjustment was not attempted except as indicated in Appendix A.

6.1.3 Chronograph

The Doppler type field chronograph provided accurate measurement of muzzle velocities. This equipment was highly satisfactory. However, it was not sufficiently well shock mounted to withstand the firing of the 280-mm gun over a protracted period of time.

6.1.4 Mitchell High-speed Camera

A Mitchell high-speed camera was used to determine the exact time of flight for all rounds. Infrared film was used to photograph the bursts. This piece of equipment proved very satisfactory.

6.1.5 Firing and Timing Circuit

The electrical circuit for simultaneously firing the weapon and starting a clock for measurement of times of flight in conjunction with the Mitchell high-speed camera proved satisfactory. The camera simultaneously photographed each burst and the exact time of flight as recorded on the clock. A comparison between these measurements and the times of flight set on the fuzes is presented in Table 6.9. These data were quite valuable in the analysis of the fuze error.

6.1.6 Weather Measurements

The meteorological data furnished were satisfactory.

6.1.7 Data Computation

The experimental data-computing system used in the tests gave adequate results.

6.1.8 Nuclear-component Delivery and Assembly

The procedures governing the delivery and assembly of the nuclear components were satisfactory. Excessive time was consumed in setting fuzes. In one case the fuze-setting equipment did not fit the fuzes. In the case of the Mark 9 (T-124) round, the fuzes had so much torque built in to ensure no slipping of the time rings that three sets of wrenches were broken while attempts were being made to set the three fuzes.

[redacted]

CHAPTER 7

ANALYSIS

7.1 METHODS OF ANALYSIS

7.1.1 Initial Analysis

An initial analysis was made based on actual data available at the time of firing. This included the metro data available at the time of firing which was generally 1 hr old. For the Ft. Sill phase of the tests, muzzle velocity had to be assumed as standard due to lack of information on the weapons used. For the NPG phase, muzzle velocities were used which had been determined by chronograph during the Ft. Sill firing. This analysis gives a fair indication of what can be expected in the field from the four methods tested. See Tables 6.1 to 6.7.

7.1.2 Final Analysis

A final analysis was made based on certain information regarding ballistic characteristics of the shells not obtained until just prior to the firing of the Mark 9 (T-124) round. Robert Schwartz, Picatinny Arsenal, one of the designers of the Mark 9 round, informed the test unit that the OST shell would develop 15 ft/sec higher muzzle velocity than the T-123 shell and that the Mark 9 (T-124) shell would develop 5 to 10 ft/sec higher muzzle velocity than the T-123 shell. The OST shells on which muzzle velocities were determined supported this.

The erratic results obtained with the MT-220 fuze on the T-123 shell and the excessive fuze errors obtained with the triple-fuze system of the Mark 9 (T-124) shell warrant consideration in the final analysis.

The final analysis was made only on the three tests fired at the NPG. In each instance the mean location of the high burst was corrected for the mean fuze error of the high-burst registration. New corrections for the verifying round were determined on the basis of this new location and were applied in place of the original corrections. The verifying round was then corrected for its fuze error and, in the case of the OST shell, for 15 ft/sec in muzzle velocity. The 10 ft/sec correction for muzzle velocity was actually applied to the Mark 9 (T-124) shell when it was fired. The results of this analysis are shown in Table 7.1 and are graphically presented in Figs. 7.1 to 7.3.

7.2 FLASH-RANGING EQUIPMENT

The presently issued equipment for plotting (board, plotting, M5) is a circular board, gridded on a 1/20,000 scale, with a diameter of approximately 21,000 m. When operated, the board is rotated under a fixed plotting arm. The board is adequate for flash ranging if the observing distance is less than 21,000 m and the base length is not more than 8000 m between flank observation posts. A deficiency of this equipment is that the plotting arm becomes

[redacted]

Table 7.1—ERROR OF VERIFYING ROUND FROM PREDICTED BURST POINT, NPG*†

Technique	Direction		Range		Height	
	Mils	Ep	Yd	Ep‡	Ft	Ep‡
			15 May 1953			
Six-round high-burst registration	0	0	+121	2.1	−21	0.6
Single spotting-round adjustment	L2	9.2	+168	2.8	+39	1.1
Muzzle-velocity error plus metro	R1	4.6	+171	2.9	−38	1.1
			22 May 1953			
Six-round high-burst registration	L0.8	3.7	−8	0.1	−53	1.5
Single spotting-round adjustment	L4.1	18.9	−32	0.5	−134	3.7
Muzzle-velocity error plus metro	R0.9	4.1	+107	1.8	−24	0.7
			25 May 1953			
Six-round high-burst registration	L1.4	6.4	+112	1.9	−76	2.1
Single spotting-round adjustment	L1.8	8.2	+178	3.0	−157	4.4
Muzzle-velocity error plus metro	R1.7	7.8	+150	2.5	−70	1.9

*Corrected for fuze error and difference in muzzle velocity between the T-123 shell and the OST and Mark 9 shells.

†In all cases a normal charge was used.

‡The percentage of error predicted for range and height in these tables does not reflect true probable errors expressed in the firing tables, inasmuch as fuze error has been removed.

Mitchell camera reading not obtained. Time of error of spotting round considered zero.

[redacted]

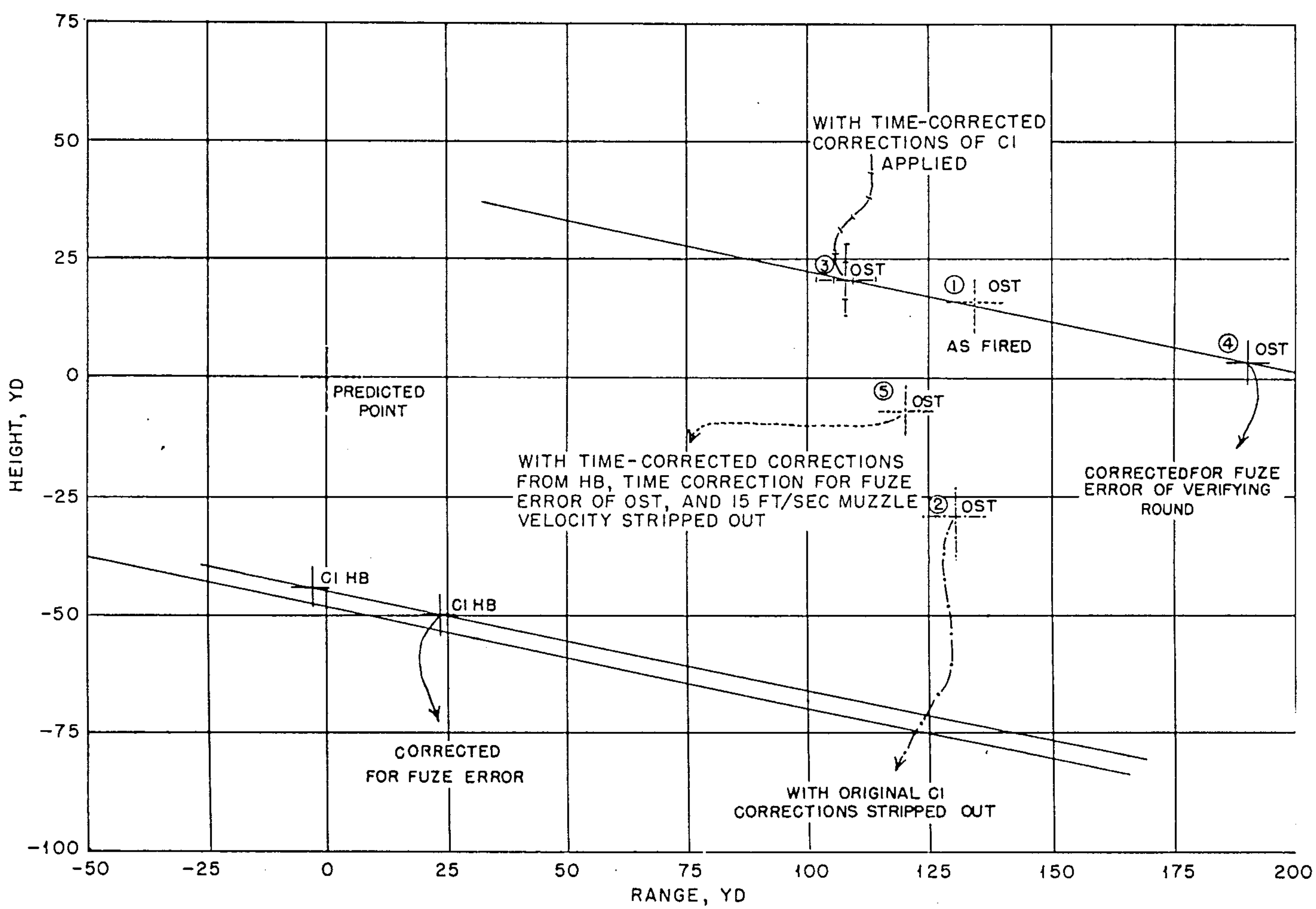

Fig. 7.1—Analysis of OST round, 15 May 1953.

[redacted]

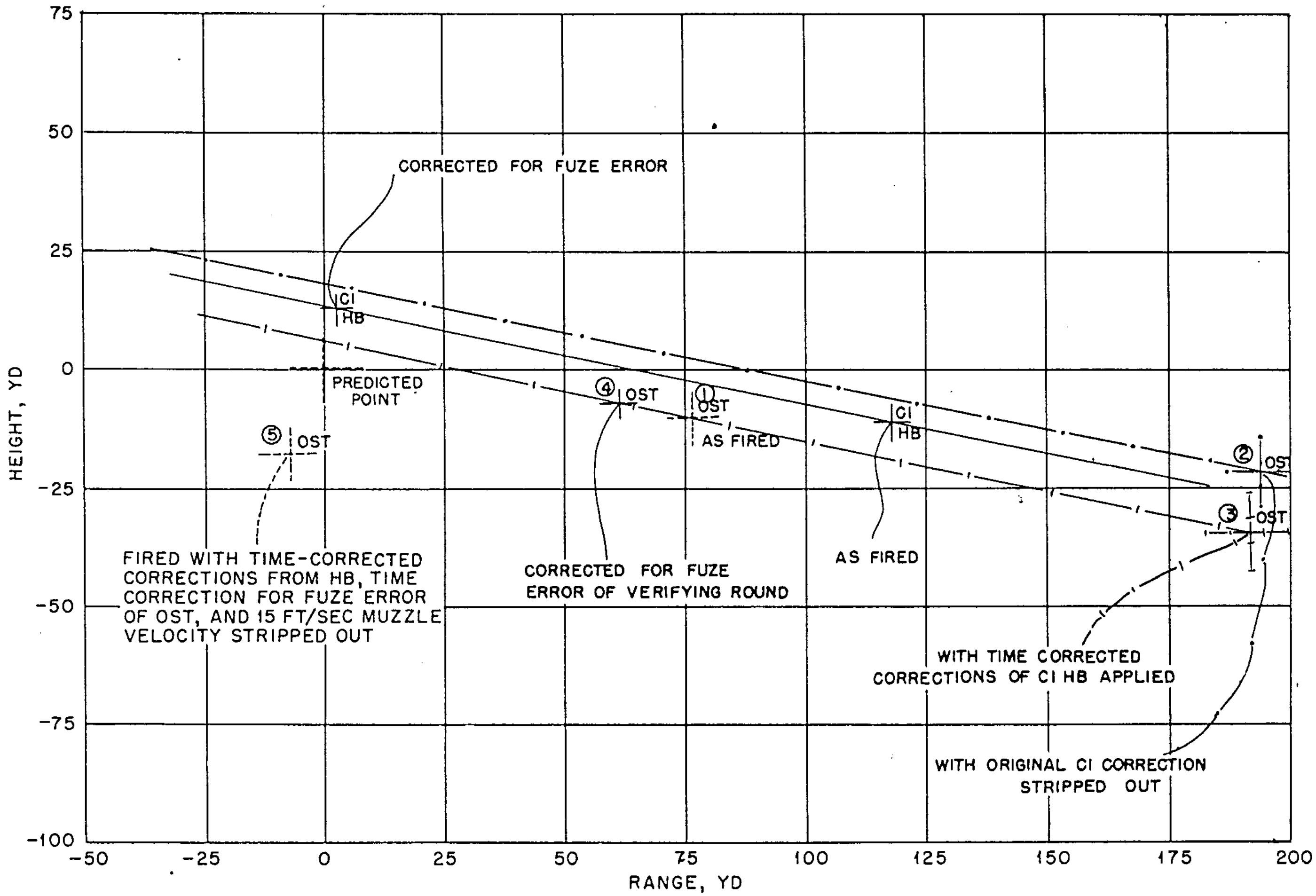

Fig. 7.2—Analysis of OST round, 22 May 1953.

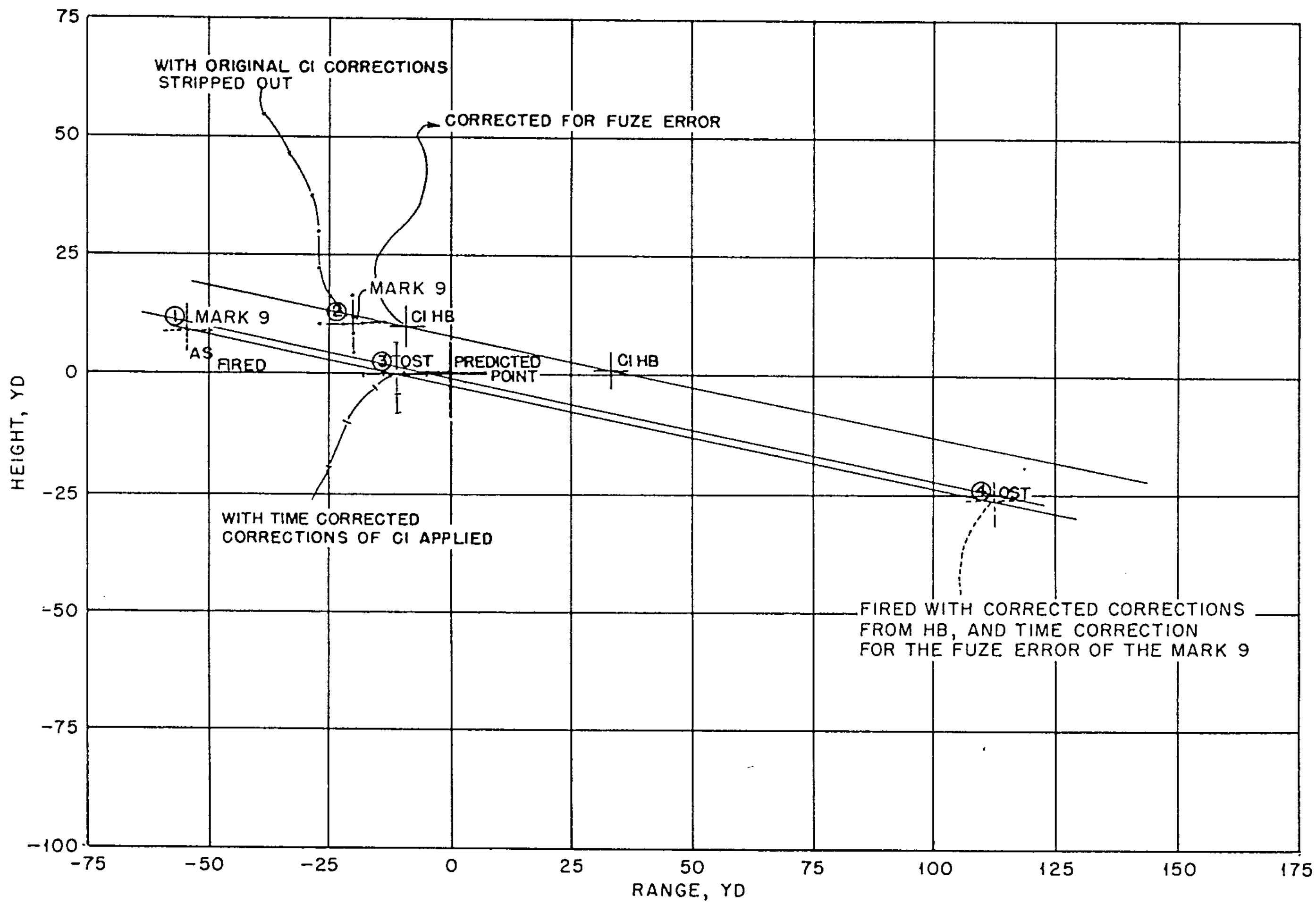

Fig. 7.3—Analysis of T-124 (Mark 9) round, 25 May 1953.

movable through an arc of 1 to 3 mils after constant field use. This error can be reduced or eliminated through careful operation. Targets at the maximum ranges of a 280-mm gun cannot be plotted on this board.

7.3 ADEQUACY OF PRESENT RADAR EQUIPMENT

Neither the AN/MPQ-10 nor the AN/MPQ-22 is adequate for registration of fire of a 280-mm gun. This is fully substantiated by the results of test, even though the radars did encounter some operational difficulties not attributable to the equipment. The solution to this problem lies in the development of suitable radar equipment. During the interim period, however, the presently available radars can be considered usable for the purposes listed below. If appropriately modified to permit beacon tracking, they will become highly useful in 280-mm gun units in maintaining proper levels of training, in facilitating further development of techniques, and in conducting silent registration within equipment capabilities.

[redacted]

CHAPTER 8

CONCLUSIONS

The six-round high-burst registration fired at the desired burst point for determination of corrections to be applied to the Mark 9 round is a satisfactory solution from an accuracy standpoint. However, it is unsatisfactory from a tactical viewpoint due to loss of surprise and exposure of the weapon to countermeasures prior to delivery of the Mark 9 round.

The one-round adjustment (or registration) fired at the desired burst point for determination of corrections to be applied to the Mark 9 round is a satisfactory solution from an accuracy standpoint. Although this method is much better with regard to tactical surprise than the six-round high-burst registration, it is still unsatisfactory from a tactical viewpoint, due to loss of surprise and exposure of the weapon to countermeasures prior to delivery of the Mark 9 round.

The use of muzzle velocity plus metro to determine corrections to be applied to the Mark 9 round is a satisfactory solution both from an accuracy and tactical surprise standpoint. With no firing prior to delivery of the Mark 9 round, complete tactical surprise is retained.

The silent adjustment using radar for locations from which corrections can be determined for the Mark 9 round proved unsatisfactory from an accuracy standpoint due to the inadequacy of the radar equipment now available.

The present battery [Table of Organization and Equipment (T/O&E)] is unsatisfactory in that it does not provide a fire-direction center sufficient to operate the fire-direction equipment.

The triple-fuze system in the Mark 9 round is unsatisfactorily arranged in the projectile. Difficulties encountered in the setting of the fuzes were too great to make the system acceptable.

The type 4 metro message is satisfactory, and improved accuracy is obtained when line numbers are interpolated for maximum ordinate.

Survey of an accuracy of 1 in 2000 is satisfactory.

The distant aiming point and base-angle method of laying are satisfactory.

The MT-220 fuze is not satisfactory because of a lack of impact element.

A requirement exists for a field type chronograph capable of measuring muzzle velocity between 1000 and 2500 ft/sec. Such a chronograph should be easily transportable and should be capable of measuring and recording velocities at any angle of elevation between 0 and 800 mils at any azimuth.

The electrical firing circuit presently employed on the gun is unsatisfactory since the positive contact provided between the breech and the firing lock is subject to slippage.

The ballistic relation between the T-123 shell and the T-124 shell is unsatisfactory due to an apparent difference of approximately 10 ft/sec in velocity.

There is a requirement for the establishment and maintenance of barrel-curvature records. It was found by test that there is a definite difference between elevation at the breech

[redacted]

and muzzle. It is sufficient to warrant correcting for this difference.

The power-ramming mechanism provided on the gun is unsatisfactory. On two of the eight days of firing, hand ramming was required when the power-ramming mechanism failed.

There is no satisfactory hand-ramming device provided with the weapon.

There is no satisfactory unloading device provided with the weapon.

A requirement exists for the measurement of length of ramming of the projectile to ensure a uniform muzzle velocity.

A need exists for the development of instrumentation to test the filament continuity of primers to be used with Mark 9 rounds.

A need exists for a more accurate fuze capable of detonating any shell used with the weapon at any point in space within the range capabilities of the weapon.

The fire-direction equipment developed at the Artillery School is a satisfactory interim solution.

Present flash-ranging methods are adequate for registration and adjustment of fire of a 280-mm gun within the range limitations imposed by board, plotting, M5.

Board, plotting, M5, is inadequate for ranging on bursts fired at the maximum usable ranges of a 280-mm gun.

Registration of fire of a 280-mm gun by radar appears promising and will be feasible upon development of proper equipment.

Radar sets AN/MPQ-10 and AN/MPQ-22 are inadequate for radar registration, but they can be considered usable and should be employed as interim equipment to maintain levels of training and to further develop techniques. Radar set AN/MPQ-10 is more suitable than radar set AN/MPQ-22.

A requirement exists for a means of improving the ability of radar sets to track projectiles in the presence of clutter.

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CHAPTER 9

RECOMMENDATIONS

Muzzle velocity plus metro (firing without registration) should be the preferred technique for delivery of the Mark 9 shell, provided sufficient knowledge of developed muzzle velocity of the gun involved is available.

The one spotting-round adjustment (or registration) fired at an auxiliary point should be the preferred technique for delivery of the Mark 9 shell if the developed muzzle velocity of the gun involved is unknown.

The six-round high-burst registration should be dispensed with as a part of the delivery technique of the Mark 9 shell.

No recommendation as to the potentiality of the silent registration can be made at this time. However, it is believed that the investigation of the field of beacon rounds for use with this weapon should be continued and that improved radars capable of tracking to the maximum range of the weapon should be developed.

The fire-direction equipment developed at the Artillery School should be adopted as standard. However, the field of electronic and/or mechanical computers should be investigated for use with this weapon.

The present T/O&E 6-535 should be re-examined and expanded to include the following additional personnel: 1 ammunition train commander (lieutenant), 1 intelligence sergeant (sergeant first class), 1 ammunition sergeant (sergeant first class), 1 senior wheel-vehicle mechanic (sergeant first class), 6 fire-direction specialists (E-5 to E-3), and 10 ammunition handlers (E-3).

The triple-fuze system in the Mark 9 round should be rearranged in the projectile to eliminate the difficulties presently encountered in making fuze settings.

Interpolation between line numbers of the type 4 metro message should be adopted as standard procedure.

Survey accuracies for this weapon should not be less than 1 in 2000.

A distant aiming point should be used for direction orientation for this weapon whenever possible. Laying by base angle should be employed when a suitable distant aiming point is not available.

The MT-220 fuze should be altered to include an impact element in order to guarantee impact burst in case of improper functioning of the time fuze.

The functional design of the MT-220 fuzes should be improved so as to reduce the probable error of fuze action (time to burst). The electric fuze should be investigated for possible use with this weapon as a means of reducing fuze-action probable error.

A field type chronograph and an operating team should be assigned to each 280-mm gun battalion. The chronograph should be capable of measuring and recording velocities between 1000 and 2500 ft/sec at any angle of elevation between 0 and 800 mils and at any azimuth.

The electrical firing circuit on the gun should be improved to provide a positive contact

[redacted]

between the breech and the firing lock.

The ballistic relation between the T-123 and T-124 shells should be revised to eliminate the present difference of approximately 10 ft/sec in muzzle velocity.

The power-rammer mechanism for this weapon should be improved to provide more stable operation.

A simple mechanical mounting device should be designed which can be used for measuring the muzzle elevation, using the standard elevation quadrant for instrumentation. The measurement should be taken with the tube at zero elevation (breech setting). This will provide for determination of barrel curvature under varying temperature conditions.

A system of records for maintaining barrel-curvature readings should be provided for each weapon. Readings should be taken and recorded for varying temperature and tube conditions.

Firing data for this weapon should incorporate corrections to elevations for barrel curvature. Elevations shown in the firing tables are based on muzzle elevations. Elevation settings in the field are based on breech elevations.

Satisfactory equipment for hand ramming should be provided for this weapon.

Equipment should be provided for this weapon for unloading projectiles.

Equipment should be provided for measuring the length of ramming.

Instrumentation should be developed for testing the filament continuity of primers which are to be used with Mark 9 shells.

Action should be taken to correct the deficiency in the plotting arm of Board, Plotting, M5.

Action should be taken to secure a plotting board suitable for flash ranging on targets at the maximum ranges of a 280-mm gun.

The development and service test of a 280-mm beacon shell should be expedited to provide an interim means of improving radar performance with respect to tracking and locating 280-mm projectiles.

Radar set AN/MPQ-10 and associated equipment should be retained for interim use in 280-mm gun battalions.

Development should be initiated under high priority to provide a radar system capable of being used with the 280-mm gun for registration and adjustment of fire.

No changes are recommended in the ballistic meteorology instrumentation and operator techniques as presently established and used in these tests. It is recommended that an investigation be conducted by the Ballistics Research Laboratories, Aberdeen Proving Grounds, to verify the validity of type 4 weighting factors for the 280-mm gun. Type 5 ballistic weighting factors for the 280-mm gun may be more correct or new weighting factors may be desirable.

Experience by meteorological personnel during these tests show the value of semiautomatic computers for artillery meteorological sections in speeding up operations and eliminating human error. It is recommended that development of such computers, which is now underway, be continued.

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APPENDIX A

RADAR OPERATIONS

A.1 MATERIEL

Radar set AN/MPQ-10 is the standard countermortar radar used in Field Artillery. It is a 10-cm (S-band) tracking type radar which provides present position data in height (yards), azimuth (mils), and horizontal range (yards), while tracking a projectile. It operates with an azimuth-elevation-range recorder RD-54/TP. The radar, mounted on a modified 40-mm gun carriage M2A1, weighs 5830 lb and is 10 ft 7 in. high in the operating position and 9 ft 3 in. high in the transport position.

Radar set AN/MPQ-22 is an SCR-584 specially modified with a large, 10-ft reflector and an automatic range-tracking unit. It is a 10-cm (S-band) tracking type radar which provides present position data in height (yards), azimuth (mils), and slant range (yards), while tracking a projectile. It operates with an azimuth-elevation-range recorder RO-3/MPQ. The radar weighs approximately 20,000 lb and is 22 ft high in the operating position and 10 ft 4 in. high in the transport position.

A.2 SPECIAL RADAR TECHNIQUE

The following technique was developed to locate either an air burst (high-burst registration) or a predicted point on the trajectory (silent registration) of a friendly artillery projectile.

The radar is laid in range, azimuth, and elevation to a "pickup" point early in the trajectory of a projectile, from which to commence tracking. A trajectory chart is required to accurately determine radar data to a "pickup" point. The radar tracks a projectile to burst or through a predicted point.

The location of the burst or of a predicted point is read from a plot of the radar track obtained from the recorder auxiliary to the radar. When a high-burst registration is employed, the point of burst is usually identified on the plot by a significant break in the range curve, which occurs when a burst saturates the radar scopes. Location of a predicted point is normally made when the range to the point is known and the azimuth and height (above radar) corresponding to that range on the plot are read. It is necessary that the operator (extrapolator) smooth the range, azimuth, and height curves prior to reading them.

If a projectile is lost prior to burst or predicted point, a "silent" location can be obtained with respect to target or predicted point by extrapolating range, azimuth, and height curves, then reading data as above, provided that the projectile is tracked to within at least 1500 yd of the target or predicted point.

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Table A.1—COMPARISON OF RADAR SETS AN/MPQ-10 AND AN/MPQ-22

No.	Characteristics and performance	Radar set AN/MPQ-10	Radar set AN/MPQ-22
1	Accuracy	Fair	Poor
2	Ease of operation	Comparable	
3	Ease of installation	Good	Poor
4	Average installation time required including preparation for action, hr	$1\frac{1}{2}$	3
5	Ease of maintenance	Comparable	
6	Mobility	Good	Poor
7	Size, weight, and configuration	Good	Poor
8	Range capability	Poor	Fair
9	Beam width	Poor (5)	Fair (2–3)
10	Data-transmission system	Good	Poor
11	Excessive corrections necessary for recorder (RD-54 or RO-3)	No	Yes
12	Interchangeability of components	Good	Poor

[redacted]

A.3 RESULTS, FT. SILL PHASE

The radar sets were emplaced as close as practicable to the line of fire in order to obtain a tail aspect (reference par. 155, FM 6-120, Field Artillery Observation Battalion and Batteries) of projectiles fired. Tail aspect was found favorable for long-range tracking of projectiles.

The radar sets tracked to burst or predicted point less than 50 per cent of the rounds fired. Radar sets were unable to track the remaining rounds to burst or predicted point principally because of interference from ground clutter.

The average spherical or three-dimensional radial error in radar locations of bursts was as follows: Radar set AN/MPQ-10, 55 yd and Radar set AN/MPQ-22, 122 yd.

A.4 RESULTS, NPG PHASE

The disposition of the radar sets was generally the same as during the Ft. Sill phase.

Both radar sets AN/MPQ-10 and AN/MPQ-22, emplaced with comparable screening crests, were rendered ineffectual in locating bursts of projectiles over Ground Zero and on targets beyond Ground Zero because of severe clutter. The severe clutter was attributed to the following causes:

1. AEC instrumentation towers, structures, and various large-size targets arrayed in the vicinity of Ground Zero.

2. Protruding hill masses rimming the Frenchman Flat area over which long-range firing was generally conducted.

The following steps were taken in an effort to improve radar performance with respect to tracking and locating projectiles:

1. All radars were emplaced successively in a number of different positions, each with varying amounts of screening crest.

2. A large metal tower located on the line of fire approximately 1 mile short of Ground Zero was removed. It had affected all radar sets. Removal of this tower increased radar tracking ranges by about 900 yd closer to Ground Zero, where the radars then locked-on other targets and clutter. Further removal of such objects was impracticable.

Silent-registration data were obtained during virtually all of the high-burst registrations by radar sets unable to track to burst (see preceding paragraph for technique).

A.5 COMPARISON OF RADAR SETS AN/MPQ-10 AND AN/MPQ-22

Although an exhaustive comparative test of these radar sets was not conducted, sufficient data were obtained and enough observations were made over a six-month period to evaluate the characteristics and performance of the radar sets when used by troops in the field. A comparison of these sets with respect to each other and to the special task in which they were employed is given in Table A.1. The comparison shows that the AN/MPQ-10 has more advantages than the AN/MPQ-22 for interim use in a 280-mm gun battalion, pending development of proper radar equipment.

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